Towards a Cloud Computing Selection and Evaluation Environment for Very Large Business Applications

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ABSTRACT

Due to their maturity Cloud Computing Services can be used for creating efficient and modern Very Large Business Applications (VLBAs). These kinds of systems address the need for more agility in the whole supply chain with a loosely coupled system of separate cloud computing services combined to a highly integrated, complex Information System. But due to the fast growth of Cloud Computing the market has become non-transparent containing many offers which only partially meet customers' requirements. That makes it even more difficult for customers to implement Cloud based VLBA-Systems. A detailed knowledge of universal Cloud requirements enables all types of customers to adopt Cloud solutions efficiently. Therefore this paper aims to contribute a framework addressing the adoption and selection of Cloud services for VLBA-Systems. To develop this framework we followed a design science approach and conducted a systematic literature review, extensive market analysis and an evaluation based on expert interviews.

Keywords

Very Large Business Applications (VLBA), Cloud Computing, Cloud Computing Selection and Evaluation Environment

INTRODUCTION

Recently, Cloud Computing has become a fast growing and non-transparent market with many providers, including heterogeneous service portfolios and models (Hoefer and Karagiannis, 2010; Martens et al., 2011a; Martens et al., 2011b). Through the increased service orientation and the new opportunities to integrate individual service models to create value-added and complex services, flexible value networks have been established (Leimeister et al., 2010) and can be used for VLBAs. VLBAs based on Cloud Computing can act as an enabler for intra- and inter-organizational distributed business processes and therefore play a significant role in the development of new markets and business models.

The lack of a universal definition and various perceptions of Cloud Computing, including the related benefits and challenges, make it difficult for many companies to profit from the Cloud concept (Leavitt, 2009; Marston et al. 2011). Barriers for Cloud Computing in VLBA-Systems are missing standards and appropriate selection requirements (Leavitt, 2009; Clemons and Chen, 2011). Furthermore, many offers do not meet - or only partially meet - customers' requirements (Forrester, 2009). The absence of defined Cloud requirements and evaluation criteria makes it difficult for customers to plan VLBA projects and implement sustainable Cloud solutions for these kinds of systems. The fact that interoperability between providers hasn't been achieved makes a provider selection often irreversible or requires much effort (Hoefer and Karagiannis, 2010).

Given this call for papers and the research gap identified, our paper aims to contribute a framework addressing the adoption and selection of Cloud services for VLBA-Systems. For this purpose we will develop a specifically VLBA-built Cloud Computing Selection and Evaluation Environment which aims to concentrate on relevant requirements for adopting SaaS Cloud Services. In this context we focus on the following research questions:

(1) What are the different adoption requirements for a SaaS service model for VLBAs?

(1) How can a Cloud Selection and Evaluation Environment look like, which supports companies to adopt and select Cloud services for VLBA-Systems?

This article is organized as follows. The first section provides an overview of the foundations and related work. Next, the research methodology and prior research is described. We then present a Cloud Computing Selection and Evaluation Environment for VLBA-Systems and give insights into this environment and its scheme. Within section four we develop the

structure of the framework based on an extensive market analysis and conducted expert interviews. After discussing the implications, the last section summarizes limitations and promising areas for future research.

BACKGROUND AND RELATED WORK

Cloud computing

A common definition of the concept of cloud computing has not yet been established in scientific literature (Weinhardt et al., 2009). By means of a literature review Leimeister et al. (Leimeister et al., 2010) have found out that cloud computing is mostly described as an IT deployment model for the on-demand, online delivery of scalable IT services on the basis of virtualization technology and pay-per-use pricing models. In this context, the term 'cloud' refers to data centers that offer virtualized computer resources and services (Armbrust et al., 2009).

Basically cloud computing is composed of five essential characteristics (according to (Grance and Mell, 2010)):

- On-demand self-service
- Broad network access
- Resource pooling
- Rapid elasticity
- Measured Service

Most researchers such as Briscoe and Marinos (2009) or Vaquero et al. (2009) and institutions like the National Institute of Standards and Technology (NIST) postulate three service models or service levels of Cloud Computing: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) (Grance and Mell, 2009; Koehler et al., 2010b).

Very Large Business Applications (VLBA)

The term "Very Large Business Applications (VLBA)" was first mentioned in (Rautenstrauch, 2005) and defined in the journal INFORMATIK SPECTRUM published in August 2007 (Grabski et al., 2007). The definition of a VLBA excludes limitations of spatial, organizational and technical manner. A VLBA is a complex system that arises from the interaction and integration of services (such as cloud services). The special characteristics such as infinity and direct effect on the business success were a novelty in the economic landscape of business computer science at this time (Grabski and Krueger, 2008). VLBAs are business applications distinguished by special characteristics of operational applications. Grabski et al, 2007 defines VLBA as follows:

- A VLBA supports one or more processes, whereof at least one is a business process. The business process has a strategic function within the organization. The replacement of a VLBA-System is connected with a large financial, human and organizational effort.
- VLBAs have no spatial, organizational, cultural or technical limitations.
- VLBAs can be implemented by using both operating systems as well as system environments. It is crucial that they support (cross-enterprise) business processes.

VLBAs are composed of different types of application systems and support multiple operational application areas such as accounting, human resources, logistics, sales and marketing (Gómez, 2009). In general VLBAs are distributed applications, which consist of a combination of many services (Jehle et al., 2008). In addition, these services are not grouped together to one system - for instance, some services are included in the form of cloud services from external providers. This heterogeneity of the system requires a special selection of individual cloud services with their assessment. For this assessment a Cloud Computing Selection and Evaluation Environment could be very helpful to have a structure requirement catalog which could be used in a standard way.

Cloud VLBA

A cloud VLBA-System is a VLBA which uses cloud services for its business functions. The technology of cloud computing can be used for modern enterprise systems like the concept of a VLBA. Currently, models of VLBAs are descriptive and to abstract to represent a cloud VLBA model. Based on the meta-model from Jehle et al. (2008) indicated extensions in the direction of web Services, Figure 1 shows a possible representation of a VLBA-architecture, consisting of cloud services.

The definition of VLBAs put humans, tasks and technologies together (Grabski et al., 2007), whereas conceptual architecture refers only to the technique aspect of a VLBA, because "humans" and "tasks" are not directly considered to be a determinant for the architecture described.

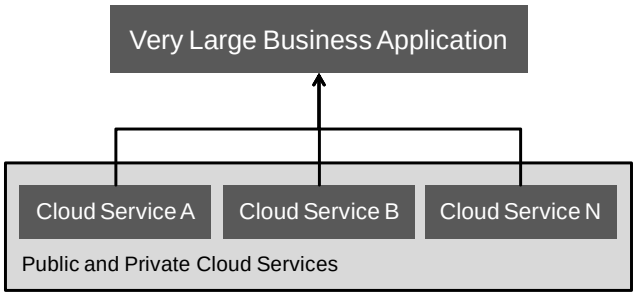

Figure 1. Conceptual Architecture Cloud VLBA

System Landscape Methodology for VLBAs

The System Landscape Methodology (SLM) is a methodology for the construction and implementation of VLBAs and can be used also for Cloud VLBAs. It was developed by the University of Magdeburg and published in 2008 (Grabski and Krueger, 2008). By bringing together the findings of the VLBA research and software engineering (e.g. life cycle model) the results are shown in the following Figure 2.

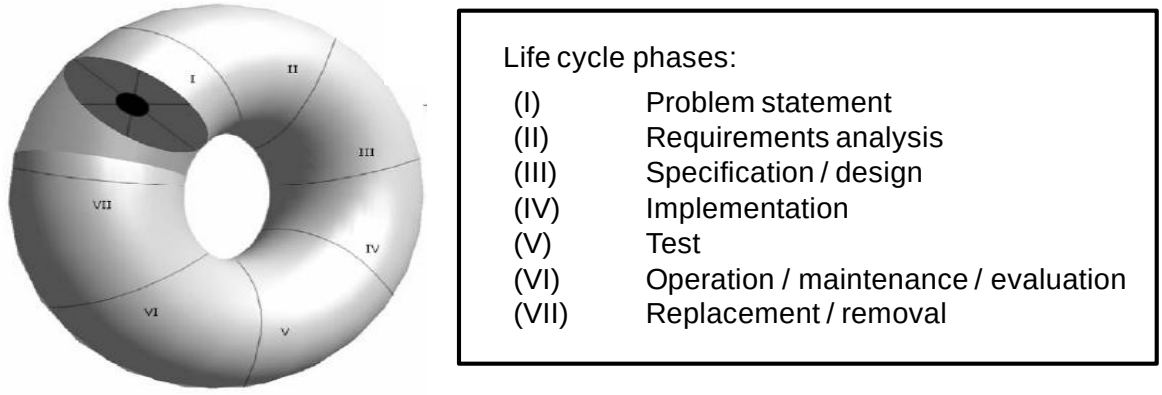

Figure 2. System Landscape Methodology Schema (Grabski and Krueger, 2008)

The shape of the scheme is reminiscent of the shape of a torus, which arises from the juxtaposition of the life cycle phases and in which the methodology is a central component of the research topics. For the name of this scheme, the term SLM has been selected. It is composed of the two English words “System Landscape” and “Methodology”. The System Landscape of a VLBA could be consisting of large quantity of different Cloud Services. These system environments (System Landscapes) constitute the technical basis for VLBAs (Grabski et al., 2007).
The Cloud Computing Selection and Evaluation Environment for VLBAs should directly support the phases II "Requirements Analysis" and III "Specification / Design" of SLM.

RESEARCH METHOD

The presented Cloud Computing Selection and Evaluation Environment for VLBAs underwent several cycles of development. The research method used in this article is based on the design science paradigm in IS research (Walls et al., 1992; March and Smith, 1995; March and Storey, 2008). The design science research is a prescription-driven and problem-solving paradigm that seeks to create viable artifacts in the form of a construct, a model, a method, or an instantiation (design artifacts) which provide solutions for management problems (Hevner et al., 2004; Gregor and Jones, 2007; van Aken, 2004). Based on the three-cycle (rigor cycle, design cycle, relevance cycle) view of design science research proposed by Hevner et

al. (2004) and Hevner (2007) we structured our research approach and began by conducting a rigor cycle and defining our knowledge base of scientific foundations. Following a rigor cycle we started to build on our existing work and conducted a systematic literature review on Cloud Computing frameworks and adoption requirements. The related work is presented in chapter "Background and related work" in the beginning.

In order to develop the theoretical foundation of our framework we started with a literature review to gather relevant requirements and aspects of existing Cloud frameworks. For this article we followed the approach of a systematic literature review by Webster and Watson (2002) and limited the search approach to the top 16.8% (21 out of 125) of all journals included in the AIS ranking list (Vom Brocke et al., 2009). Table 1 lists all literature sources that were examined to identify relevant papers and key words.

Publication type	Publisher	Key words
Journals	ACMSIG, CACM, CAIS, CompDcsn, DATABASE, DSI, DSS, EJIS, I&M, I&O, IBMSJ, IEEEComp, IEEESw, IEEEIC, IEEETC, IEEETKDE, IEEETrans, IEEETSE, IEEETSMC, IJEC, IJHCS, InfoSys, ISF, ISJ, ISM, ISR, IT&M, IT&P, JACM, JAIS, JCIS, JComp, JCSS, JIM, JITTA, JMIS, JSIS, KBS, MISQ, MS, SMR, WIRT	Cloud Vendor, Cloud Characteristics, Cloud Classification, Cloud Selection, Cloud Taxonomy, Cloud Computing Infrastructure as a Service, IaaS, Platform as a Service, PaaS, Software as a Service, SaaS Very Large Business Applications, VLBA, Cloud Evaluation
Conferences	AMCIS, ECIS, ICIS, HICSS, IEEE Conferences, LNI, LNCS, MKWI, PACIS, WI	
Associations, Organizations, Companies	Cloud Security Alliance (CSA), EuroCloud, Bitkom, Bundesamt für Sicherheit in der Informationstechnik (BSI), Securing Europe's Information Society (ENISA), Center for Experimental Researchin Computer Systems (CERCS), Fraunhofer SIT, Distributed Management Task Force (DMTF), The European Telecommunications Standards Institute (ETSI), National Institute of Standards and Technology (NIST), Open Grid Forum (OGF), Object Management Group (OMG), Open Cloud Consortium (OCC), Organization for the Advancement of Structured Information Standards (OASIS), Storage Networking Industry Association (SNIA), The Open Group, TM Forum, SaaS EcoSystem, OpenCloudManifesto, Experton Group, T-Systems	

Table 1. Journals and conferences investigated for the literature review and key words

The results of the rigor cycle were used for the initial design cycle. In this research step, we designed a first draft of requirements relevant for the adoption and selection of Cloud services based on existing knowledge. We also constructed a first version of the Cloud Computing Selection and Evaluation Environment for VLBA and assured that during this phase the results were revised against the requirements until a satisfactory design was achieved. We then conducted three iterations of a relevance cycle to evaluate our framework and gather information about adoption requirements.

In the first iteration we discussed these requirements and the first draft of our framework in two separate workshops with four and three experts (see Table 2). As a result of the workshops we developed a four level hierarchy to illustrate targets, requirements, evaluation criteria and measurable indicators (see Figure 3). The first level (targets) is necessary to capture the intension and objectives of the customer regarding the Cloud adoption. The second level (abstract requirement) was defined to limit and aggregate the indicators to a manageable level. The third level (evaluation criteria) was defined to cover aspects ("soft criteria") which cannot be measured and compared easily. The fourth level (key performance indicators, KPI) is defined to realize an assessment and controlling basis, e.g. relevant for a Cloud benchmarking. By means of the experts and the literature review we derived the relevant target dimensions for Cloud Computing (Wind et al., 2011) and defined two types of scope of the requirements (provider requirement and service requirement).

(Expert from) Company type	Company data	Position within company	Cloud experience
IT service provider	170.000 employees Global IT service offerings 10-15% revenue based on Cloud Computing Innovative solutions in IaaS	Senior Vice President of Cloud Business (W2)	Deep understanding of Cloud Computing (IaaS, PaaS and SaaS)
IT service provider	SME software company 20 employees Development of standardized components for web-based services	CIO (W1), Software architect (W1)	Expert know-how in IaaS and PaaS
IT service provider	Start up company in the field of SaaS 32 employees Developing of digital record and human resources solutions	CEO (W1)	Expert know-how in developing, maintenance and distribution of SaaS.
IT service provider	Start up company offering SaaS solution for newsletter delivery	CEO (W2), CIO (W2)	SaaS and IaaS expertise
Consulting company	International consulting company 500 consultants worldwide Cloud Computing as one consultancy topic	Partner	Current consulting focus; Cloud market appreciation
Customer / Client	Automotive sector ca. 95.000 employees	Divisional director IT	Experience in selecting, implementing and operating IaaS and SaaS
Customer / Client	SME software company 11 employees Development of standardized components for web-based services	Software architect (W2)	Expert knowledge in IaaS and PaaS especially in the implementation

W1 = Participant at workshop 1 W2 = Participant at workshop 2

Table 2. Type of experts interviewed

The second iteration was a market analysis regarding all three service models like IaaS, PaaS and SaaS where provider and service aspects were gathered and mapped to the prior defined hierarchy. This analysis was based on an extensive internet research where the websites of relevant companies were examined regarding their pricing model, Cloud service offering, company data and customer segment. By means of market studies, business publications on the Cloud market and an extensive internet search we detected over 60 relevant providers for IaaS, 82 relevant providers for PaaS and over 1000 providers for SaaS, mostly located in the US. Due to essential differences on each service level we decided to draw a distinction between requirements specific to one or two service models and requirements valid for all three service models (independent of service model) (Weinhardt et al., 2009).

The third iteration and final evaluation consists of expert interviews to evaluate the developed framework including the structure, the mapped requirements and evaluation criteria. In total nine experts were selected from seven companies, all holding different positions within their companies (see Table 1). Care was taken that those respondents were representing complementary perspectives (provider, customer, integrator, and consultant). The interviews with the experts were structured and conducted referring to Glaeser and Laudel (2010). The final result of our research is the evaluated framework which will be presented afterwards.

CLOUD COMPUTING SELECTION AND EVALUATION ENVIRONMENT FOR VLBA'S

In the following we describe the developed cloud requirement framework. First we give an overview of the framework's structure. Afterwards we give an introduction into the target dimensions and describe subsequently the abstract requirements and evaluation criteria of the framework.

Structure of the Cloud Computing Selection and Evaluation Environment

The framework consists of two parts, the Cloud Computing target dimensions and the Cloud requirements (see Figure 3). The target dimensions - such as cost savings or increasing flexibility – represent objectives which the customer pursues and may characterize its IT strategy or especially the related Cloud strategy (Wind et al. 2011). These dimensions cover the Cloud Computing in its entirety and are not limited to VLBAs or another service model (e.g. IaaS).

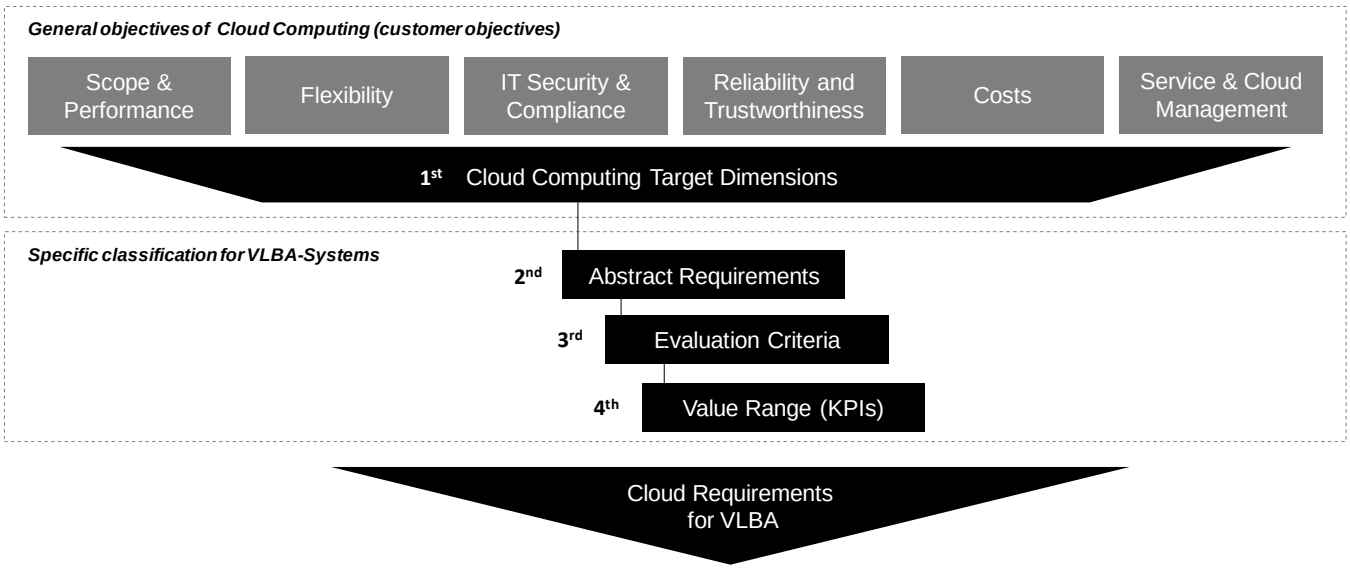

Figure 3. Scheme of the Cloud Computing Selection and Evaluation Environment

The target dimensions can be broken down into comparable Cloud requirements for VLBAs. The Cloud requirements are structured in a four level hierarchy. First abstract requirements (second level) are defined and mapped to the target dimensions (top level). On the third level evaluation criteria are described that are comparable but not necessarily measurable. The fourth level finally defines the value range and measurable indicators.

Target Dimensions

The target dimension "Scope & Performance" covers the functionality and performance of the Cloud service and consists of two abstract requirements for VLBAs: Service Characteristics and Service Optimizing. To select the appropriate provider which meets the VLBA requirements best, knowledge about their services and performance is of crucial importance.

The dimension "Flexibility" describes the ability to respond quickly to changing capacity requirements and competition pressure. It is divided for VLBA into four abstract requirements: Interoperability, Portability, Delivery Model, and Automatization Degree. Flexibility describes the ability to respond quickly to changes. Besides, other aspects such as standardization (e.g. APIs), the traceability of data, the short-term contracts or a demand driven and scalable resource recovery have to be considered.

The target dimension "IT Security & Compliance" summarizes everything related to protection and safety and is composed of three abstract requirements for VLBAs: Network Protection, Operations Protection and IT Compliance. The decision on selecting a provider in the Cloud is often influenced by company and government requirements in the areas of security, compliance and privacy. Given the critical importance of VLBA systems for a company, there are high demands on this dimension. The companies have to be certain that their data and applications, even operated in the Cloud, meet both compliance guidelines required and are adequately protected against unauthorized access.

The target dimension "Reliability & Trustworthiness" describes how certain the customer in a VLBA-System can be that the service from the Cloud has the guaranteed availability. It is divided in three abstract requirements: Reliability, Trustworthiness and Service Level Agreements. The commitment by the Cloud service provider, especially the guaranteed availability, is very important for VLBAs. Moreover, the reliability which these commitments are kept with is of great importance.

The last target dimension "Service & Cloud Management" includes aspects necessary for the Cloud management and the maintenance of the relationship between customer and provider. It can be differentiated according to three abstract requirements: Provider Management, Service Management and Transformation Management. These include the offered support and functions for controlling and monitoring as well as transformation support. In a distributed IT architecture like VLBA this target dimension is very important and should be equal on a rational level between the different Cloud service providers.

Abstract requirements and evaluation criteria of the Cloud Computing Selection and Evaluation Environment

One of the aims of this paper is to develop a Cloud Computing Selection and Evaluation Environment to support companies to adopt and select Cloud services for VLBA-Systems. The developed framework consists of six target dimensions (top level), 18 abstract requirements (second level), 45 evaluation criteria (third level) and a value range (including KPIs if possible) for each evaluation criteria. In Figure 4 we focused on illustrating the Cloud requirements regarding their relevance for VLBA-Systems. For this reason the KPIs were not shown and only mentioned in the next sections.

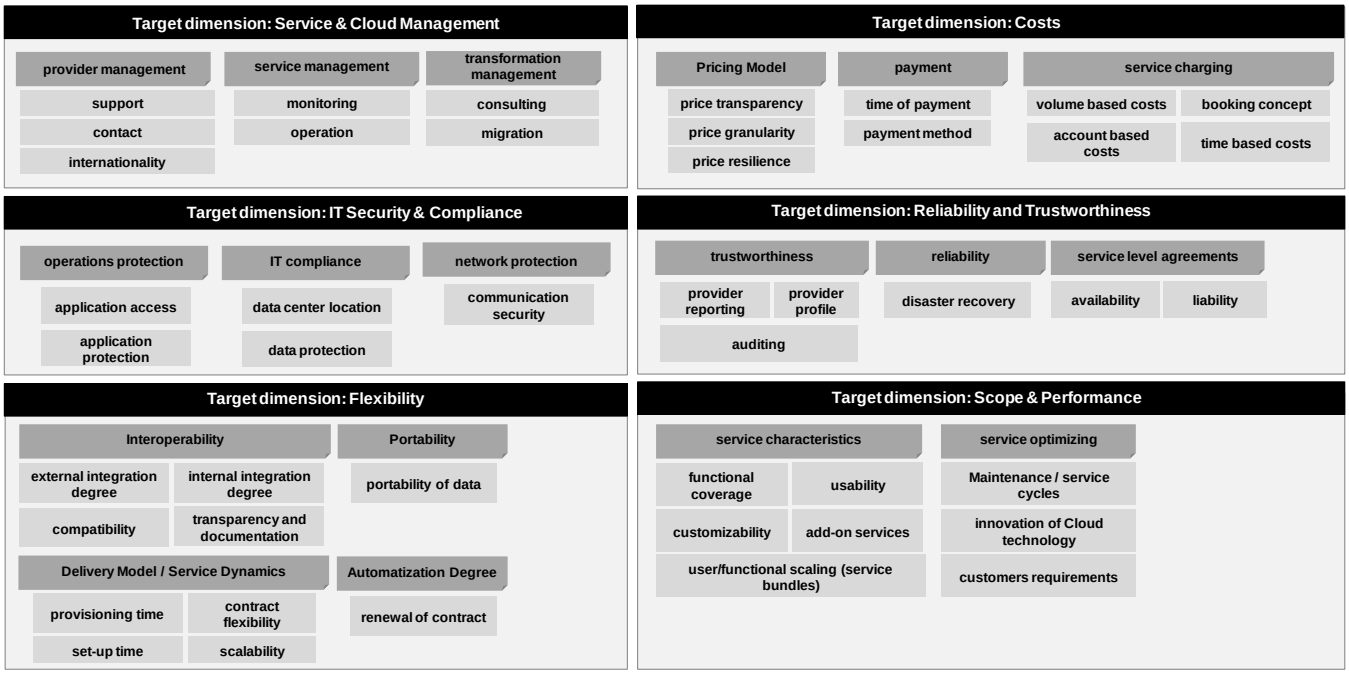

Figure 4. Abstract requirements and evaluation criteria of the Cloud Computing Selection and Evaluation Environment for VLBAs

Service & Cloud management

Provider management contains support, contact and information about internationality of the provider. This criterion considers all facts regarding support and customer service, e.g. which support is offered and under which conditions. For VLBA-Systems this information is quite important to know and every Cloud service provider must execute the defined SLAs for the whole system. Furthermore it contains information about the internationality, e.g. multilingual support, several offices or local contact options. *Service management* includes all activities necessary to control and manage the obtained Cloud services which are subsumed in this criterion, e.g. monitoring of services and volume control via APIs. *Transformation management* describes consulting and migration support for VLBA implementation projects.

Costs

Payment and pricing models are shaped by monetary considerations regarding the decision to choose Cloud Computing and a particular provider. The payment opportunities include the possible payment method (e.g. credit card or bank transfer), the time of payment (pre-paid or post-paid) and which level of granularity is priced (e.g. 10 User Account, 100 User Account or 500 User Account steps). *Service charging* defines how the service is charged (volume based, time based, account based) and the available booking concept, e.g. pay per use, subscription fee, market based prices (spot pricing).

IT Security & Compliance

IT compliance is separated into network protection (e.g. communication security), operations protection (e.g. application access and application protection) and IT compliance (e.g. location of data center). Even standards, identity management and other data privacy requirements are considered. *Communication security* refers to the provided infrastructure and focuses on the communication protection via secure cryptographic protocols (e.g. SSL) and dedicated firewall settings. VLBA-Systems

normally deal with mission-critical information, so these criteria are very important. And it is not unusual that especially in this area the company has to deal with stricter limitations and security requirements. *Operations protection* includes the access management and role concept related to the used services.

Reliability & Trustworthiness

Trustworthiness characterizes the provider and its business activities, including performance and service transparency (e.g. reports, service description), market experience, the number of customers or the annual revenue. *Disaster recovery* describes activities related to regularly backups, snapshots and data mirroring in other locations. *Availability and liability* include the probability that service commitments and promises can be met by the provider, based on indicators like the service availability, accessibility to several internet service providers and the liability agreements including penalties if the guaranteed service level is not met. In a distributed VLBA, the entire system could be standstill when only one Cloud service fails. Due this reasons the criteria could be very useful in the specification phase within the System Landscape Method.

Flexibility

Delivery Model / Service Dynamics with Provisioning, Set-up time, Scalability and Contract Flexibility are subsumed under the associated flexibility advantage of Cloud Computing for VLBAs. Resources, for instance, can be allocated and de-allocated as required. The provisioning time is shorter compared to traditional outsourcing and the set-up time to get in contact with the provider (e.g. register or set up a new account) is shorter as well. *Scalability* comprises all features regarding the maximal number of available resources (e.g. user accounts, instances, functions, services) which can be used simultaneously. Additionally the interoperability describes the integration degree separated into internal communication (between services of the provider) and external communication (between services of different providers). The browser compatibility is important especially on the SaaS level. *Contract flexibility and renewal of contract* both represent the commitment between the customer and the provider (e.g. contract length) and defined contract automatisms (e.g. cancelation period).

Scope & Performance

Service characteristics describe the relevant service features. These include predefined customizing templates, functional coverage, usability, add-on services etc. Usability and customizability refer to the usability and adaptability of the surface of the web portal, the user interacts with. The Usability mainly represents the structure and the ease of use following the self-service concept. Regarding individual preferences predefined templates, editable user views and function settings can be configured by the user. This is an important functionality for VLBAs. Through this it would be possible to reach the same design for each service within the whole system. Add-on services describe additionally bookable services like storage, database services, communication services (e.g. collaboration, messaging) or security services. Service optimizing deals with continuous service development, improvement of service functions and maintenance cycles. Functional coverage & scaling is directly related to the service usage and covers the offered functionalities for SaaS.

IMPLICATIONS, LIMITATIONS AND FUTURE WORK

The objective of this article was to design a Cloud Computing Selection and Evaluation Environment which helps companies to adopt Cloud Services for VLBA-Systems. VLBAs based on Cloud Computing can act as an enabler for intra- and inter-organizational distributed business processes and therefore play a significant role in the development of new markets and business models. To achieve this, Cloud Computing Services can be used due to their maturity for creating such systems. But Cloud Computing has become a non-transparent market with a huge amount of new providers and many offers which only partially meet customers' requirements on a second view. That makes it difficult for customers to use Cloud Services in VLBA-Systems. There are important factors and considerations for the decision to adopt Cloud Computing in this field. Therefore this paper presents a framework addressing the adoption and selection of Cloud services, which can be used to standardize the selection process and find propriety services in a professional way. For this purpose the framework could be used as an efficient enhancement to the existing System Landscape Methodology for VLBAs in the phase "Requirements analysis" and "Specification / design".

Implications for science and business practice: The presented framework has an impact on most of the research fields of Cloud Computing we described in section two. With its requirements covering a SaaS service model for VLBA-Systems this framework can be seen as a contribution to achieve more transparency to the Cloud Computing market..Furthermore, providers can exploit the evaluation criteria to enhance their business portfolios and focus on the right aspects of Cloud VLBAs. On the other hand customers will be guided by means of this framework to adopt and implement Cloud VLBA solutions, especially for selection and comparing providers or to advance the comprehension of Cloud Computing. The

consequence is a shift from a subjective service assessment to a mostly fact-based performance selection where the realization of service requirements is gaining importance. In this context Cloud integrators and aggregators are becoming more relevant to advice customers and to realize a Cloud VLBA-System which allows the combination and communication between several Clouds and services of different providers.

Our previous research on Cloud target dimensions and selection frameworks was limited to only one Cloud service model: Infrastructure as a Service (IaaS). In this article we now have enlargement this for the service model SaaS and especially for VLBA-Systems. This was a necessary step because VLBA-Systems are mission-critical and the requirement, specification and selection process is of crucial importance.

A limitation of the presented framework is the number of workshops held with various experts, more of them will be held in future additionally. Another limitation is the lack of prioritization of the Cloud requirements and evaluation criteria. In this article we do not provide an adoption approach how the framework exactly can be used for VLBAs. The customer has to decide individually in which way he wants to use this framework, dependent on its purpose. This can be quite different based on the possible use cases of this framework.

In our future research a next step will be the implementation of the framework within a practical case together with the System Landscape Methodology. This may help to gain broad range experience regarding long-term usage and to improve the framework step by step. Furthermore we are planning to conduct several case studies with Cloud customers to evaluate and prioritize the framework and its requirements for VLBAs. Thus, future research will be directed to extend and to evaluate our existing measurable KPIs of the Cloud Requirement Framework and to examine how a feasible Cloud controlling can be realized.

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